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Eco-Friendly Cow's Milk Production in Organic and Biological Farming Systems

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Abstract

The production of environmentally safe products is a pressing issue for many countries worldwide. In the post-war period, Ukraine's agricultural sector will require new, science-based technologies to restore production and ensure the production of ecologically safe cow's milk. A study was conducted to assess the ecological state of Ukraine's forest-steppe zone, steppe, and woodlands, along with an analysis of organic and biological agriculture. The findings were supported by experimental research on producing ecologically safe milk. The experiment involved dairy cows of the black and red-speckled breeds, adhering to methods commonly accepted in zootechnical practice. For each sample, the average value (M) and standard deviation (SD) were calculated, with estimates presented as M ± SD. Differences between mean values were considered statistically significant at $P<0.05$, and the calculations were performed using the STATISTICA software package version 10.0. Environmental pollution by cadmium (Cd) and lead (Pb), resulting from industrial activities and mining, has negatively impacted agroecosystems. There are successful examples of organic and biological farming in Ukraine, with dairy products from agricultural enterprises meeting both national and international quality standards. The experiment tested methods to improve the technology of producing eco-safe milk by feeding dairy cows a special mineral-vitamin premix combined with a phytobiopreparation, which enhanced the excretion of toxicants through excrement and resulted in the production of ecologically safe milk in compliance with EC Regulation No. 853/2004 and No. 1881/2006. The use of manure as an organic fertilizer in organic farms necessitates systematic monitoring of pollutant migration in the soils of livestock farms. Further research is needed to understand the impact of pollutants on the somatic cell content in milk.

Keywords

Manure; Heavy metals; Organic waste; Ecological safety; Agro-ecosystem; Dairy cows

Introduction

The study of the production of ecologically safe milk, particularly with respect to heavy metal content on cattle farms across various countries, remains a pertinent issue, influenced by both natural and anthropogenic factors (Özbay, Dikici and Soylukan, 2023). In volcanic regions worldwide, soil and water can become contaminated with heavy metals. In a study conducted by Turkish scientists, Özbay, Dikici and Soylukan (2023), the potential for producing milk containing arsenic, aluminum, nickel, cadmium, and lead within acceptable environmental safety standards was assessed in the province of Aksaray, a dairy hub situated near Hasandağı, an extinct volcanic mountain. Over six months, the scientists collected and analyzed samples of feed, water, and milk to determine the content of heavy metals. Their findings revealed that the concentration of pollutants in milk was significantly lower than in feed and water. Additionally, the proximity to the volcano did not affect the levels of mineral elements in the water, milk, and feed. However, the researchers established a significant relationship between seasonal changes and the concentration of mineral elements in the samples studied. For instance, the concentration of aluminum in feed was recorded at 298,290.1 µg/kg, whereas the aluminum level in milk was substantially lower, at 96.15 µg/kg. The highest cadmium concentration in milk was observed in the spring, averaging 0.06 µg/kg, while lead peaked in the summer at an average of 2.14 µg/kg. Arsenic levels in milk from regions close to the volcanic zone showed little variation with distance, averaging 1.01 µg/kg near the zone and 0.94 µg/kg in more remote areas. The highest level of heavy metals in milk was nickel, reaching 182.08 µg/kg during the summer months. While the study highlights the impact of natural sources of heavy metal contamination on ecosystems, the situation in Ukraine presents a stark contrast. Here, the environment faces not only increased anthropogenic pressures but also the devastating effects of full-scale military operations. The use of a wide range of artillery, mines, missile ammunition, and armored vehicles, along with the destruction of critical infrastructure, hydro-technical facilities, solid waste landfills, water canals, oil reservoirs, and entire cities and regions, has severely impacted the environment. Thousands of hectares of fertile agricultural land, including areas used for livestock production, have been mined.

In the post-war period, it will be crucial to restore agricultural production, employing modern, effective, and proven organizational, technological, and ecological methods to conduct organic and biological farming. This includes the production of ecologically safe cow's milk that meets both domestic and international environmental safety standards, particularly regarding heavy metal content (Mamenko, Zandaryan and Portyannyk, 2021).

Scientists from India emphasize the crucial role of milk in human nutrition, particularly for children, due to its high content of protein, calcium, and vitamins, which are vital for cognitive development. However, the potential danger posed by heavy metals in milk, stemming from environmental factors and the transfer of toxic metals from feed, has drawn the attention of researchers worldwide (Alam *et al*., 2024). In a study conducted in Bengaluru, a southern Indian metropolis, researchers investigated seasonal fluctuations in the intake of heavy metals — cadmium, chromium, and lead — by dairy cows. They measured the concentration of these pollutants in fodder, milk, and excrement across 39 dairy farms located in urban and suburban areas. Due to a shortage

of fodder, farmers in this region often rely on fodder grown near lakes and polluted sites, which carries the risk of heavy metal contamination from uncontrolled sources. While significant concentrations of toxicants were found in cattle excrement, the study confirmed that the milk itself remained safe for consumption. However, the researchers noted a potential risk of re-contaminating the soil with organic fertilizers that contain elevated levels of toxic metals (Alam *et al*., 2024).

Effective agrarian production of ecologically safe, high-quality agricultural products is closely tied to addressing the challenges of state regulation in the development of organic and biological agriculture in Ukraine. This includes strengthening partnerships among local citizens for the restoration of territories and promoting sustainable development. A key focus is supporting the transition of farms and private peasant holdings to organic and biological farming methods. In the post-war period, Ukraine will possess significant potential for producing organic and biological agricultural products, both for domestic consumption and export. Domestic scientists stress the need to develop and implement a National Program for the Greening of Agriculture by 2030, which would include establishing a monitoring system for rural areas, reinforcing state policies to preserve soil fertility, protect against degradation, and creating a national framework for assessing anthropogenic emissions. This initiative aims to prevent the negative impact of such emissions on organic agriculture and public health (Pysarenko *et al*., 2019).

Soil is one of the primary sources of anthropogenic impact on organic and biological agriculture, as well as on animal and human health. It is in the soil that various pollutants, including toxic heavy metals like cadmium, lead, and mercury, tend to accumulate. Cleaning contaminated soil, particularly in the post-war period, will be a long and multi-year process, requiring the use of various physico-chemical, microbiological, and other methods. One of the most well-known methods is the removal of the topsoil layer, though this is a very radical and expensive approach, typically reserved for cases of severe radioactive contamination. Other methods include stabilizing toxicants within the contaminated areas, relocating pollutants to deeper soil layers to prevent absorption by plant roots, and employing bioremediation with microorganisms. Additionally, techniques such as phytoremediation, phytoextraction, and phytodegradation, which involve using plants to remove or degrade contaminants, can also be utilized.

In general, limiting the negative anthropogenic impact on the environment in the post-war period will be extremely challenging, but it is a goal that must be pursued by both scientists and practitioners. The destruction of Ukraine's shunting thermal power industry has caused significant environmental damage, with 90% of the infrastructure now destroyed. It is essential to restore these energy capacities on an ecological basis, supported by an effective system of environmental control and analysis. Environmental impact assessments should be conducted using scientifically grounded approaches, which include determining the degree of environmental risk, evaluating the effectiveness of environmental protection measures, and preparing well-founded conclusions on environmental impact. It is also crucial to inform the public and businesses about these assessments. There should be broader implementation of ISO 14000 series standards for organizing and managing environmental protection activities. As part of its association with the European Union, Ukraine adopted a new Law "On Environmental Impact

Assessment" in 2017[1], replacing the outdated "Law on Environmental Expertise." This new legislation has made the environmental assessment procedure for planned activities by economic entities more transparent and less susceptible to corruption, while also encouraging greater public participation in addressing the environmental challenges associated with economic development within communities.

The purpose of this research is to justify the production of ecologically safe livestock products in compliance with domestic and international requirements, the development of organic and biological agriculture in Ukraine, taking into account today's challenges and for the post-war period.

Materials and Methods

This study analyzes the ecological state of agro-ecosystems in Ukraine's forest-steppe, steppe, and woodland regions, as well as the status of organic and biological agriculture in these areas. The research includes experiments on producing ecologically safe milk and monitoring the state of agrobiogeocenoses on farms within these soil and climatic zones. During the scientific experiment with black and red-speckled dairy cows, average samples of feed and milk were collected following standard zootechnical practices. Ecological monitoring of ecosystems has been ongoing since 2000 and continues in accordance with the stages of R&D development, as per State registration number 0121U113933 dated November 18, 2021. Biochemical analyses of plant-origin samples (feed) and milk for macro- and microelement content, as well as toxic metals, were conducted using atomic absorption spectrophotometry (AAS-30 spectrophotometer) (Praice, 1972). The analysis was based on the researchers' own studies, domestic and international legal documents, and scientific publications. Various methods, including monographic, analysis and synthesis, empirical, and comparative methods, were employed in this work. Biometric data analysis considered the characteristics of the obtained results, including sample size, data distribution type, and variance nature. For each sample, the mean value (M) and standard deviation (SD) were calculated and reported as M ± SD. Differences between mean values were considered statistically significant at $P<0.05$. The calculations were performed using the STATISTICA software package version 10.0.

Results and Discussion

Farmers worldwide often face the dilemma of whether to manage their farms traditionally or adopt organic practices. This choice can have a significant impact on both the farm's financial performance and its environmental footprint (Bang *et al*., 2024). Researchers have compared the profitability of conventional and organic cattle farming systems, considering factors such as feed production and quality, milk quotas, and the capacity of livestock facilities. They conclude that when high-quality feed is readily available but expansion of livestock is restricted due to animal limits and milk quotas, organic farming may become more favorable than traditional farming. Conversely, when these constraints are absent, traditional farming tends to maximize gross profit. These

[1] Law of Ukraine "On Environmental Impact Assessment" dated 05/23/17 No. 2059-VIII 04/1/2022. URL: https://zakon.rada.gov.ua/laws/show/2059-19#Text

findings underscore the crucial role of feed production capacity and quality, as well as available milk quotas and infrastructure, in determining whether to transition from conventional to organic farming (Bang *et al*., 2024). We concur with this assessment, as the quality, ecological safety, and cost of feed significantly influence farmers' decisions on their farming approach. Norwegian scientists, including Bang *et al*. (2024), also emphasize the importance of providing equal incentives for organic farming across regions, suggesting that organic payments should be regionally tailored to align with other state payments that are already region-specific.

Today and in the post-war period, there will be an urgent need to restore agricultural production and increase food production in Ukraine. Compared to other countries, the per capita consumption of organic products in Ukraine is very low, with citizens spending an average of only 0.5 Euro per year on organic products. In contrast, the figure is 274 Euros in Sweden (Tereschenko and Mylovanov, 2018). Developing organic production is a key aspect of environmentally-oriented agricultural practices, where product quality, ecological safety, and the rational use of natural resources are paramount. Organic production is regulated by the fundamental standards of the International Federation of Organic Agriculture Movements (IFOAM), the Codex Alimentarius of the Food and Agriculture Organization of the United Nations (FAO) and WHO, as well as European Union directives, including No. 2092/91 of June 24, 1991, and No. 834/2007 of June 28, 2007 (Tereschenko and Mylovanov, 2018).

In 2018, Ukraine adopted a new law titled "On Basic Principles and Requirements for Organic Production, Circulation, and Labeling of Organic Products[2]". This law is intended to regulate the production of organic and biological products in line with international standards of quality and environmental safety, and to facilitate the export of these products to the European market. The law is especially important for consumers who choose organic products, as it ensures that the quality of these products aligns with the stated standards. Additionally, the law aims to support the increase in organic milk production within the country (Pysarenko *et al*., 2019).

Scientists have established that the mammary gland of dairy cows does not serve as a barrier against heavy metals. When cows ingest feed contaminated with toxic metals like cadmium and lead, these metals can pass into the milk, thereby reducing its quality and environmental safety. This issue may become more pronounced in areas affected by mining or other military activities following the end of hostilities. In an experiment with dairy cows, we conducted a chemical analysis of milk samples (n=5), which revealed elevated levels of cadmium in the first control groups with different feeding types: 0.087 ± 0.008 mg/kg (silage-root feed), 0.09 ± 0.085 mg/kg (silage-hay), 0.068 ± 0.017 mg/kg (silage-hay), and 0.053 ± 0.019 mg/kg (silage-hay-concentrate), compared to the standard limit of 0.03 mg/kg. Similarly, lead content was found to be 1.835 ± 0.093 mg/kg (silage-root feed), 1.641 ± 0.253 mg/kg (silage-hay), 1.734 ± 0.148 mg/kg (silage-hay), and 1.794 ± 0.165 mg/kg (silage-hay-concentrate), against the norm of 0.02 mg/kg.

To produce ecologically safe milk, we fed the cows in the second research group a specially developed antitoxic mineral-vitamin premix. In the third group, we enhanced

[2] https://www.fao.org/faolex/results/details/en/c/LEX-FAOC183666/

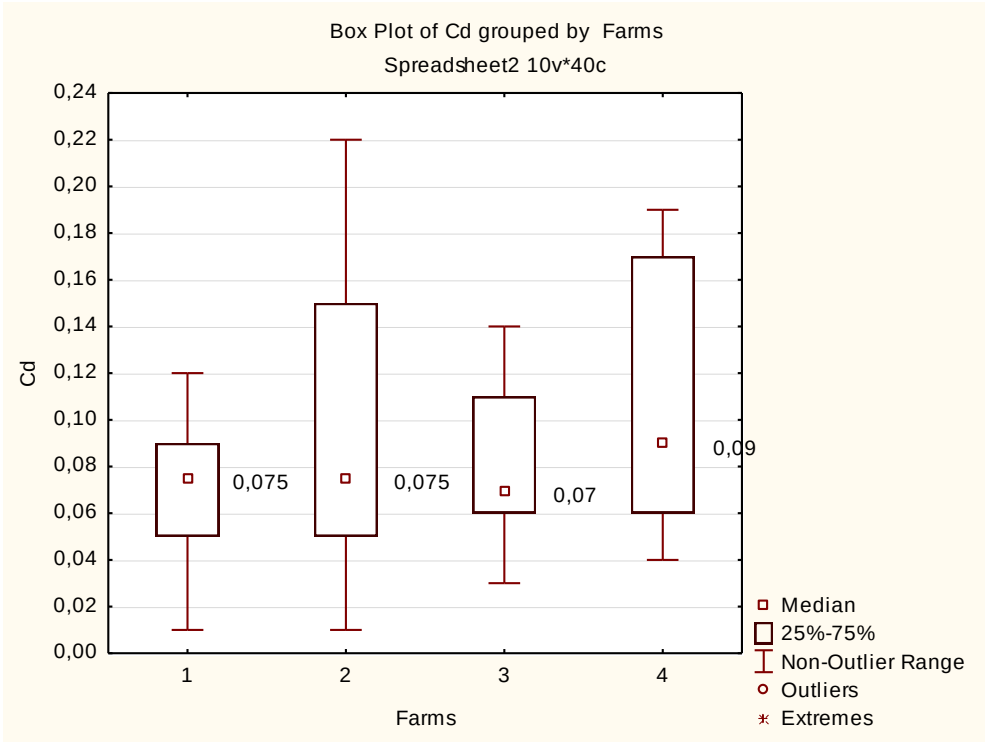
the effect of this premix by administering a phytopreparation containing an extract of *Eleutherococcus senticosus*. Blocking the absorption of toxic metals in the gastrointestinal tract reduced their transfer into the bloodstream and, consequently, into the milk ($P<0.01$). By the end of the 120-day experiment, we successfully produced milk from cows in the third experimental group that met both domestic and international standards, including EC (European Commission) Regulation No. 853/2004 and No. 1881/2006 (Table 1). The levels of cadmium and lead were 0.018 ± 0.002 mg/kg (Cd) and 0.014 ± 0.003 mg/kg (Pb) for silage-root feed, and 0.012 ± 0.002 mg/kg (Cd) and 0.014 ± 0.004 mg/kg (Pb) for silage-hay feed. The statistical significance compared to the control group was ($P<0.01$). Thus, our study demonstrated that the combined use of a premix and an herbal preparation derived from the extract of nine medicinal herbs can effectively reduce the load of toxic heavy metals such as cadmium and lead in dairy cows, leading to the production of ecologically safe milk.

Table 1: Toxic metals in the milk of cows at the end of the experimental period (M ± SD)

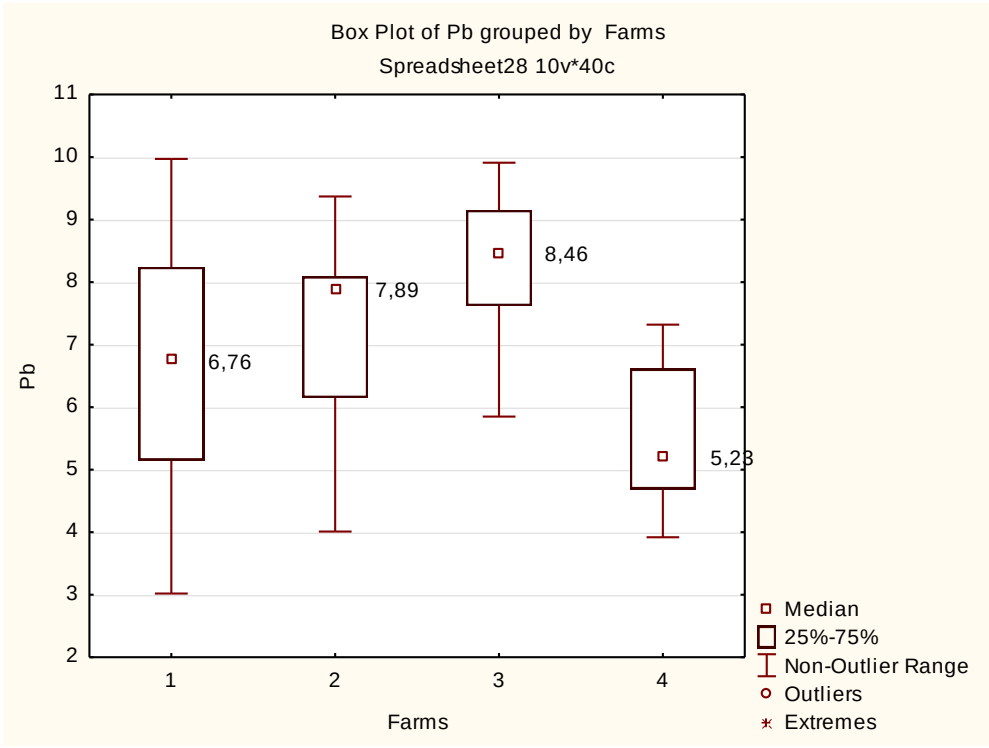
Animal feeding type	*Mineral elements*	*Cow groups*		
		1 control	*2 experimental*	*3 experimental*
Silage-root	Cd, mg/kg	0.087 ± 0.008	0.031 ± 0.005	0.018 ± 0.002
	Pb, mg/kg	1.835 ± 0.093	0.614 ± 0.085	0.014 ± 0.003
Silage-hay	Cd, mg/kg	0.09 ± 0.085	0.031 ± 0.008	0.011 ± 0.003
	Pb, mg/kg	1.641 ± 0.253	0.515 ± 0.064	0.027 ± 0.012
Silage-haylage	Cd, mg/kg	0.068 ± 0.017	0.017 ± 0.004	0.012 ± 0.002
	Pb, mg/kg	1.734 ± 0.148	0.016 ± 0.004	0.014 ± 0.004
Silage-haylage-concentrate	Cd, mg/kg	0.053 ± 0.019	0.024 ± 0.009	0.014 ± 0.004
	Pb, mg/kg	1.794 ± 0.165	0.331 ± 0.064	0.032 ± 0.008

Note: The degree of reliability in comparison with the data of the control group is $P<0.01$; $n = 5$.

Increasing the elimination of xenobiotics from cows' bodies leads to higher concentrations of these substances in organic waste. Cattle manure, which consists primarily of excrement and bedding material, plays a crucial role in maintaining the ecological safety of agroecosystems, especially since it is often used as an organic fertilizer for crops (see Figure 1 and Table 2). When practicing both traditional and organic agriculture, it is essential to consider this factor. Proper application rates of organic fertilizers per hectare of agricultural land must be followed, and manure should be applied differentially, taking into account the specific needs of the plants and the characteristics of both fodder and technical crops. In a study by Marchand *et al.* (2024), dairy cows were fed mineral supplements containing high concentrations of cobalt, manganese, and zinc. The study found no positive effect on nutrient digestibility throughout the gastrointestinal tract, including the rumen. Additionally, no increase in milk productivity was observed during lactation. However, the excretion of these pollutants increased in proportion to their introduction into the diet. This raised concerns about soil contamination following the application of such organic fertilizers and highlighted the need to study the long-term environmental impacts.



a)



b)

Figure 1. Quartile diagram of the median content of cadmium (a) and lead (b) in organic cow waste (mg/kg)

Table 2: Concentration of heavy metals in manure of dairy cows of experimental farms, mg/kg (M ± SD)

Heavy metal	*MPC of gross forms in the soil*	*Manure from manure storages of experimental farms, n=10*			
		№1	*№2*	*№3*	*№4*
Cd	3	0.07 ± 0.035	0.09 ± 0.07	0.08 ± 0.037	0.11 ± 0.057
Pb	32	6.73 ± 2.29	7.32 ± 1.69	8.25 ± 1.24	5.48 ± 1.18
Cu	55	42.18 ± 5.36	39.93 ± 6.72	47.42 ± 4.78	37.71 ± 4.91
Zn	100	74.95 ± 5.70	76.65 ± 5.34	66.55 ± 4.28	81.49 ± 3.34

To transition to organic production, a farmer must submit an application to the appropriate authority. The transition period to organic farming officially begins once the certification body signs the service provision contract, enabling the farmer to qualify for state support. Enterprises aiming to enter the EU market must obtain both a domestic and an international certificate. In Ukraine, plant-based organic production is more developed than animal-based organic farming, which requires significant investment (Pysarenko et al., 2019).

In the initial years of transitioning to organic farming, yields will not match those of traditional farming, and during this transition period, farmers cannot sell their products as organic. According to scientists (Borghino *et al*., 2024), organic farming has gained attention as a sustainable agricultural practice worldwide, but it also faces challenges due to its lower productivity. While European organic farmers benefit from substantial financial support, the situation in Ukraine regarding payments to agricultural producers upon EU membership remains uncertain. Nevertheless, organic production is considered one of the most promising sectors for the development of Ukraine's agro-industrial complex.

Organic and biological agriculture are priorities in the state agrarian policy, and over the past decade, the area dedicated to organic farming has increased by 1.7 times (Chaika *et al*., 2019). Organic and biological animal husbandry can be more effective when integrated with crop farming, as imported feed is costly, making the resulting products expensive and less competitive in the market. One of the pioneers in organic farming in Ukraine is the private agricultural enterprise "Agroecology" in the Poltava region, which has not used pesticides or plowing for over 40 years and has avoided mineral fertilizers for more than two decades. The farm enriches the soil using green manures, perennial grasses, and plants rich in NPK, such as alfalfa, asparagus, and buckwheat. The farm's cattle herd supplies organic fertilizers. An important social aspect of organic farming is the significant increase in employment, nearly doubling the number of workers needed compared to traditional farming. For example, if traditional farming requires 100 workers, organic farming may employ 200-250 workers. The farm has achieved high levels of efficiency in dairy cattle breeding, with continuous growth in livestock numbers. The success of any farm in developing organic and biological agriculture depends on the parallel advancement of both crop and livestock farming, beginning with dairy cattle breeding followed by meat production.

The enterprise is certified according to Swiss standards and as a producer of milk for baby food. It is also certified as a breeding farm for the Ukrainian red-spotted dairy breed and as a breeding center for the Aberdeen-Angus meat breed. Many of its products are

exported to EU countries, demonstrating that environmentally-friendly farming practices are viable. Organic farming ensures stability in development, with dairy herds producing an average of 6,600 kg of milk per cow on organic feed. However, changes in taxation, rent, and production costs have risen with increased expenses. In 2018, the agricultural enterprises "Organic Milk" and "Gles Agro" from the Zhytomyr region were among the top five of 300 officially registered domestic organic farms. "Galex Agro" breeds Simmental cattle under the conditions of the Polissia region, a breed well-suited to organic and biological production. The average yield from these cattle is 7,300-7,400 kg of milk, with high quality: bacterial contamination does not exceed 50,000/cm³, somatic cell count is up to 180,000/cm³, fat content is 4.0-4.5%, and protein content is 3.0-3.2%. The calf yield is 96%. Simmentals are highly adaptable and resistant to stress, with a productive longevity of 7-9 lactations. Manure is composted before being applied to fields, at a rate of about 30 tons per hectare. Livestock care practices are humane, minimizing animal suffering, with isolation and restraint only used in extreme cases and for limited durations.

The examples of farms practicing organic agriculture in various soil and climatic zones of Ukraine demonstrate that their operations are guided by the fundamental principles of organic agriculture as outlined by IFOAM - Organic International: the principle of ecology, the principle of fairness, the principle of health, and the principle of care. Their experience highlights the potential for biosafe production of both plant and animal-based food products.

Modern agricultural production significantly impacts the natural environment, affecting air, water, soil, nutrient cycling, and often contributing to soil erosion and carbon absorption issues. Danish scientists, Giagnoni *et al*. (2024), studied the effects of different types of carbohydrates in silage and concentrate diets on gut methane production — a contributor to the greenhouse effect — and milk yield in cows. The researchers tested the impact on intestinal methane emissions by feeding cows clover or corn silage as the sole feed source (55% dry matter), combined with barley or dried beet pulp as a concentrate. They measured methane emissions and milk productivity, finding that diets rich in starch led to the lowest intestinal methane emissions. Since methane from dairy cows is a major source of anthropogenic greenhouse gases, it is crucial to reduce these emissions. Therefore, in Ukraine, any increase in cattle numbers during peacetime should be accompanied by balanced feeding strategies to reduce methane emissions and mitigate global warming and climate change. Organic farming plays a crucial role in minimizing environmental impact and promoting sustainable, balanced development, as supported by many scientists worldwide (Gamage *et al.*, 2023).

Conclusion

The production and processing technology for livestock products under organic-biological agriculture involves numerous factors, with the primary focus being the environmental safety of the products, such as milk and meat. By incorporating eco-friendly agricultural practices and developing new technological methods — tested in experiments involving a premix and a phytopreparation — we can enhance existing technologies. This approach will ensure the production of environmentally safe milk that complies with both domestic and international standards, such asEC Regulation No.

853/2004 and No. 1881/2006, even under challenging environmental conditions in the post-war period.

Applying manure as an organic fertilizer on farms practicing organic-biological agriculture requires systematic monitoring of pollutant migration in the soils of agricultural lands, particularly in pastoral farms for dairy cows in forest-steppe and other agricultural zones. It is essential to employ non-traditional methods of manure processing, such as composting, cultivating vermiculture, using synanthropic fly larvae, or producing biogas. Manure produced from fodder with heavy metal concentrations exceeding the maximum permissible concentration (MPC) by 20 times or more should be applied only to industrial crops, with restricted use on vegetable and fodder crops. Composting manure by mixing it with peat, soil, straw, and sawdust—materials with lower heavy metal content—can also help reduce the concentration of toxicants in the manure.

Organic and biological agriculture, along with the production of livestock products, offer undeniable advantages over traditional agriculture in terms of ecological safety, biological integrity, and high quality. These practices should be grounded in the use of environmentally sound technologies that promote the sustainable circulation of substances within the natural environment. Further research is needed to explore the impact of incorporated heavy metals on the somatic cell count in the milk of dairy cows.

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Author's Declarations and Essential Ethical Compliances

Author's Contributions (in accordance with ICMJE criteria for authorship)
This article is 100% contributed by the sole author. He conceived and designed the research or analysis, collected the data, contributed to data analysis and interpretation, wrote the article, performed critical revision of the article, edited the article, and supervised and administered the field work.

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has involved dairy cows (body or organs) for experimentation. The research was not based on laboratory experiment involving cattle. Other contexts of animals were only indirectly covered through literature review. Therefore, an ethical obligation of ARRIVE applies in cases of this study or written work. The ARRIVE Checklist is appended.

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The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, prior informed consent (PIC) of the respondents or a Self-Declaration in this regard is not applicable for this article.

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The author(s) solemnly declare(s) that this research has not involved the plants for experiment and field studies. Some contexts of plants are also indirectly covered through literature review. Yet, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research Involving Local Community Participants (Non-Indigenous) or Children
The author(s) solemnly declare(s) that this research has not directly involved any local community participants or respondents belonging to non-Indigenous peoples. Neither this study involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

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The ARRIVE guidelines 2.0: author checklist

The ARRIVE Essential 10

These items are the basic minimum to include in a manuscript. Without this information, readers and reviewers cannot assess the reliability of the findings.

Item		Recommendation	Section/line number, or reason for not reporting
Study design	1	For each experiment, provide brief details of study design including: a. The groups being compared, including control groups. If no control group has been used, the rationale should be stated. b. The experimental unit (e.g. a single animal, litter, or cage of animals).	a. The experimental population was divided into three groups: the first control and the second and third research groups. The results obtained in the second and third experimental groups were compared with the results of the first control group of animals. b.Cows of all groups were fed feed with the content of heavy metals Cd, Pb, Cu, Zn above the established maximum permissible concentrations. Animals of the second experimental group received an additional special antitoxic mineral-vitamin premix "MP-A", and the third – a premix and subcutaneous injection of the biological product "BP-9", which includes an extract of nine medicinal plants. The experiments were conducted in four farms that specialize in the production of cow's milk.
Sample size	2	a. Specify the exact number of experimental units allocated to each group, and the total number in each experiment. Also indicate the total number of animals used. b. Explain how the sample size was decided. Provide details of any *a priori* sample size calculation, if done.	a. For the first experiment, 126 cows with silage-hay-concentrate type of feeding were selected, ie 42 animals in each group; the second - 63 animals with silage-haylage – in each group of 21 cows, the third - 36 heads with silage-root - in each group of 12 heads and in the fourth - 195 with silage-hay type of feeding, where in each group there were 65 goats respectively. A total of 420 dairy cows were used for the experiments. b. The sample size of animals for each experiment was determined by the kept livestock in agricultural enterprises to which the method of analogues by age, live weight, milk productivity, lactation period could be applied. Since the animals were selected for the experiment by the method of analogues, for laboratory tests of blood, urine, milk for the content of the studied pollutants were randomly selected from each group of 5 cows.
Inclusion and exclusion criteria	3	a. Describe any criteria used for including and excluding animals (or experimental units) during the experiment, and data points during the analysis. Specify if these criteria were established *a priori.* If no criteria were set, state this explicitly. b. For each experimental group, report any animals, experimental units or data points not included in the analysis and explain why. If there were no exclusions, state so. c. For each analysis, report the exact value of *n* in each experimental group.	a. Criteria for selection of dairy cows in the group for scientific and economic experiment were the same age, lactation period (4), live weight (500-545 kg); dairy productivity. b. The groups did not include animals that had a high difference in live weight, cows that had significantly higher milk productivity, which could affect the results in terms of the effect of pollutants and antidotes on the average daily milk yield. Animals with the first, second and third lactation periods were not included. Sick animals were also not selected. All animals were examined by a veterinarian. Only healthy animals were involved in the experiment. c. Since the animals were selected for the experiment by the method of analogues, for laboratory tests of blood, urine, milk for the content of the studied pollutants were randomly selected from each group of 5 cows.
Randomisation	4	a. State whether randomisation was used to allocate experimental units to control and treatment groups. If done, provide the method used to generate the randomisation sequence. b. Describe the strategy used to minimise potential confounders such as the order of treatments and measurements, or animal/cage location. If confounders were not controlled, state this explicitly.	a. All animals on the dairy farm, especially those involved in the experiment, were constantly under the control of a veterinarian and in case of changes in health associated with premix feeding or biopreparation, intoxication, etc., cows would be removed from the experiment, and the experiment is stopped. No such facts were established during the 120 days of the experiment. b. Specialists and workers of the respective dairy farm were constantly involved in order to avoid obstacles, failures in experiments and to achieve the maximum " purity" of the experiment for sampling blood, urine, milk, carrying out decadal control milkings, weighing animals, etc. In particular, a veterinary paramedic, a zootechnician, milkmaids, and other pastoralists.
Blinding	5	Describe who was aware of the group allocation at the different stages of the experiment (during the allocation, the conduct of the experiment, the outcome assessment, and the data analysis).	Regional and district heads of the veterinary medicine department, respectively the management and engineering and technical workers of the farms where scientific and economic experiments were conducted knew about the staging and conducting of the experiments. Management of the Kharkiv State Veterinary Academy, Head of the Department of Applied Ecology named after O.A. Kolesova Professor Mamenko O.M.
Outcome measures	6	a. Clearly define all outcome measures assessed (e.g. cell death, molecular markers, or behavioural changes). b. For hypothesis-testing studies, specify the primary outcome measure, i.e. the outcome measure that was used to determine the sample size.	a. No significant changes in the health of the experimental animals and their behavior during the experiment were detected. According to the external appearance, the animals of the second and third experimental groups had the best condition. Animals of these same groups were more lively, lively. b. To establish the correspondence of the obtained data to the law of "normal" distribution (Gaussian), we applied the Shapiro-Wilk's W test, which is considered the most powerful, especially in small samples (n <50) of independent groups.
Statistical methods	7	a. Provide details of the statistical methods used for each analysis, including software used. b. Describe any methods used to assess whether the data met the assumptions of the statistical approach, and what was done if the assumptions were not met.	a. The analysis of the data was carried out taking into account the peculiarities of the results obtained in the study: the size of the sample and the type of distribution of the data, the nature of the variances. For each sample, the mean value of the characteristic in the sample (M) and the standard deviation (SD) were calculated, the estimate is given as M ± SD. Disagreements between mean values were considered statistically significant at P <0.05. The calculation was carried out using the STATISTICA software package version 10.0. b. The Shapiro-Wilk's W test made it possible to determine the appropriate method for further analysis of the comparison of samples. Considering that the sample size is insignificant, the most effective way to apply the nonparametric analysis of variance Kruskal-Wallis (or H-test) (Kruskal-Wallis ANOVA).
Experimental animals	8	a. Provide species-appropriate details of the animals used, including species, strain and substrain, sex, age or developmental stage, and, if relevant, weight. b. Provide further relevant information on the provenance of animals, health/immune status, genetic modification status, genotype, and any previous procedures.	a. The experiment was performed on cattle, in particular, dairy cows with 4 lactation periods, live weight 500-545 kg, average daily milk yield 14-15 kg. b. Experiments were carried out on dairy cows of Ukrainian black and red-and-white dairy breeds.
Experimental procedures	9	For each experimental group, including controls, describe the procedures in enough detail to allow others to replicate them, including: a. What was done, how it was done and what was used. b. When and how often. c. Where (including detail of any acclimatisation periods). d. Why (provide rationale for procedures).	a. Cows of all groups were fed feed with the content of heavy metals Cd, Pb, Cu, Zn above the established maximum permissible concentrations. Animals of the second experimental group received an additional special antitoxic mineral-vitamin premix "MP-A", and the third – a premix and subcutaneous injection of the biological product " BP-9", which includes an extract of nine medicinal plants. In the second and third research groups, the rations for feeding dairy cows developed by us were additionally balanced, adapted to the actual daily ration, with a special antitoxic mineral-vitamin Premix "MP-A". b. The dose of administration of the preparation "BP-9" – 20 ml/day with the division of this norm into two, 10 ml each in the morning and at intervals of 12 hours in the evening. The frequency of administration of the preparation is 5 times a month, with an interval of administration – once every 5 days. The course of the use of the preparation is 3 months. The biological product contains the following elements: P, Ca, Mg, S, Fe, Mn, Cu, I, Se, etc., vitamins: A, D, E, B12, B3 (niacin, PP), B4, B5, C, H (Biotin) and one of the sulfur-containing amino acids. Feeding the premix based on the introduction of 5% into the diet was: for cows with silage-root crops and silage-hay type of feeding 250 g per head per day, silage-hay-concentrate - 200 g, silage- hay - 200 g, respectively. c. The experiment was conducted around the industrial city of Lubny in Poltava region during the stall period. d. The expeirment was conducted based on the results of ecological monitoring of agro-ecosystem pollution by heavy metals and the need to develop new effective environmentally friendly technological methods for the production of environmentally friendly high-quality cow's milk.
Results	10	For each experiment conducted, including independent replications, report: a. Summary/descriptive statistics for each experimental group, with a measure of variability where applicable (e.g. mean and SD, or median and range). b. If applicable, the effect size with a confidence interval.	a. The accumulation of Cd in the blood of test cows in control groups was on average from 77.94 to 103.20 nmol / L, Pb - from 4.63 to 6.02 μmol / L. The transfer of Cd from blood to urine was on average 1.7 to 2.0 %, Pb - 5.4-7.2 %. Elimination of heavy metal data from the body with milk - Cd - 0.0035-0.0045 %, Pb - 0.0004-0.0005 %, respectively, in the first - third. There was a chronic form of toxicosis. The applied antidote-substances contributed to the exacerbation of heavy metal extermination from the body of animals and the restoration of its homeostasis. In other experimental groups of cows, the transfer of Cd from blood to urine averaged 3.9 to 5 %, Pb - 37.7-53.5 %, respectively, in the third - from 7.1 to 12.7 % Cd and 70.7-84.1 % Pb. The combined effect of the antitoxin premix and the biopreparation in the third experimental group of cows gave a better result of the removal of toxic elements from the body. b. The complexity of the experiment, the financial costs of laboratory tests, etc., as well as the general difficult economic situation in the field of dairy farming in Ukraine did not contribute to the re-conduct of a similar scientific and economic experiment in a particular region. experiments.